Why are Sunsets Red?

Through a series of experiments, students learn light travels in waves, how light is separated and the reason sunsets have brilliant colors.

Grade Level: 5th

Phenomena:
What is the scientific reason behind why Nevada has amazing sunsets?

Objectives:

- Students will identify parts of nature that are being modeled in the sunset experiment.
- Students will describe why sunsets are commonly red and orange.

Materials:

- Electromagnetic spectrum poster
- Medium glass tank - fish tank
- Water
- Whole milk
- Flashlight
- CDs
- Small lights - enough for each pair of students
- Prism

Appendixes:

- Student worksheet: Page 7
- Summary of electromagnetic spectrum: Page 8

Time Considerations:
Preparations: 20-25 minutes
Lesson Time: 50-60 minutes

Introduction: 15 minutes
Activity 1: 10-15 minutes
Activity 2: 5-10 minutes
Activity 3: 10 minutes
Activity 4: 5 minutes
Conclusion: 5 minutes

Related Lesson Plans:
Solar Energy, Energy Sleuths, Sun Rays

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Next Generation Science Standards

5-ESS2-1.
Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

Science and Engineering Practices (SEP):
Developing and using models

Disciplinary Core Ideas:
Earth materials and systems.

Crosscutting Concepts:
Systems and system models.

Excellence in Environmental Education Guidelines

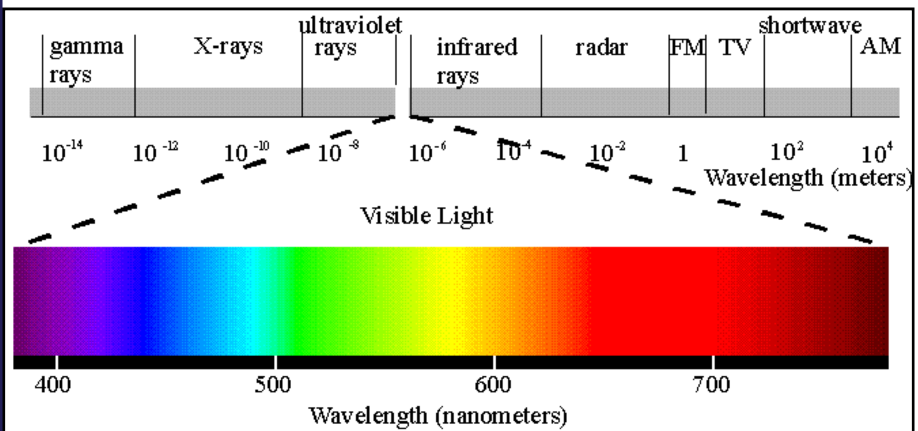
Strand 2.1—The Earth as a Physical System

C) While they may have little understanding of formal concepts associated with energy, learners are familiar with the basin behaviors of different forms of energy.

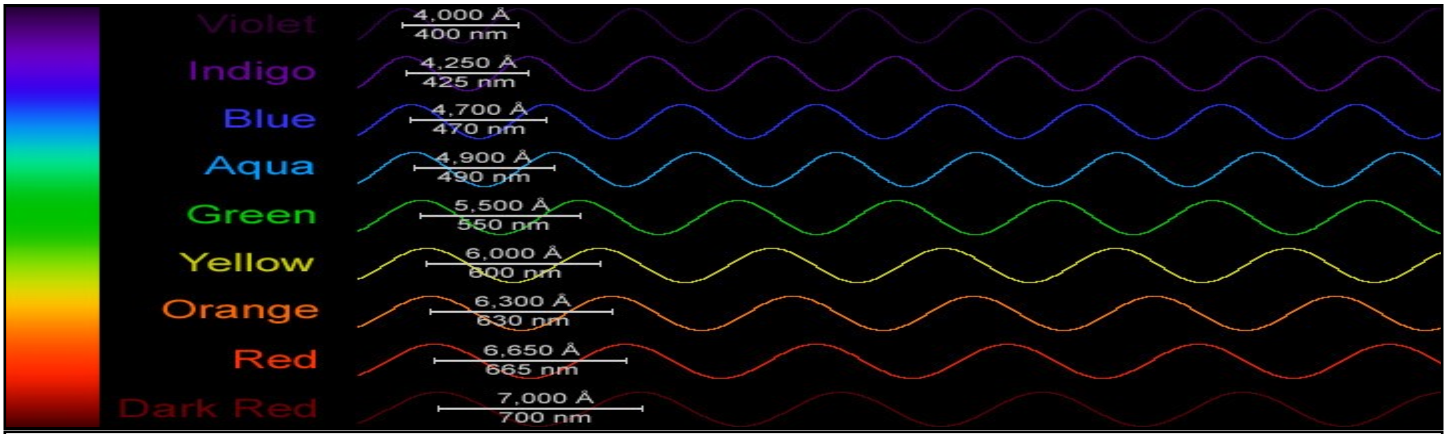
Background

Solar radiation, light from the sun, provides light and heat to life on Earth. When light is analyzed it is referred to as the electromagnetic spectrum. The electromagnetic spectrum consists of several types of waves including radio, micro, infrared, ultraviolet, visible, X-Ray and gamma ray - more Information can be found on page eight. However, the receptors in our eyes respond only to the narrow range of wavelengths called visible light (*BBC*).

When all the wavelengths of visible light are together, visible light is seen as “white light.” It is only when these wavelengths are separated, does visible light appear in different colors. The visible

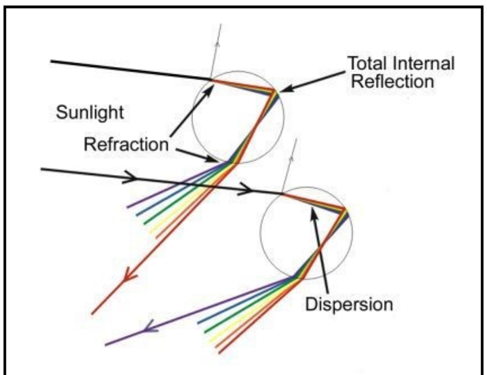


Visible light spectrum



Visible light spectrum

light spectrum consists of an infinite number of colors that range from red to violet—as seen in the above picture. Our eyes cannot perceive all the subtle differences in the spectrum, so instead our eyes see the major changes from one color to another (*Randy, R.).*



Light refraction in raindrops

In order for these different colors to be seen, visible light must be separated. This happens by way of refraction. A beam of light that is refracted has been bent and moved in another direction. Raindrops, prisms, and other media such as glass are examples of tools that refract light. This explanation is why rainbows exist. The vast amount of water molecules in the atmosphere provides the appropriate medium to refract or separate light, resulting in the display of colors seen in a rainbow (*Physics Planet*).

Each wavelength of color, in the visible light spectrum is unique to one another. All the wavelengths travel at the same speed, but have different frequencies. Frequency is the number of peaks and troughs of a wavelength that occurs between two points. Therefore wavelengths found to the left side of the spectrum, violets and blues, have longer frequencies compared to the right side of the spectrum, oranges and reds, which have shorter frequencies. This has been determined and supported through numerous fields of science including astronomy (*Randy, R.)*.

So what are factors contribute to the brilliant colors of sunsets? The answer is a combination of atmospheric particles and refraction. As light passes through the atmosphere it comes in contact with water molecules, dust, pollutants and other particles. Due to these particles light is either refracted or scattered in different directions. The size and concentration of atmospheric particles determine the type of sunset observed. When there are few particles in the atmosphere, most wavelengths of light reach the observer's eyes with almost equal intensity. When there is a heavy concentration of particles, the shorter wavelengths of light, violet and blue, are scattered. Longer wavelengths, reds, oranges and yellows, due to the distance between each peak and trough, are maneuvered around the particles resulting in a red sunset *(Department of Atmospheric Sciences).*

Another reason that contributes to the colors of sunsets deals with the angle at which light travels across the sky. At noon, light typically enters the atmosphere close to a ninety degree angle. This angle results in less distance light travels through the sky, which minimizes the encounter of atmospheric particles. In the


Sunset in Winnemucca, Nevada

evenings however, light travels at a much smaller angle across the horizon. Light therefore travels farther through the sky and the probability of contacting atmospheric particles are much greater. Thus, at the smaller angle, sunsets are redder due to the other wavelengths being refracted and scattered (*Department of Atmospheric Sciences).*

The sunsets in the western United States are well known for their amazing colors. Which differs from the eastern portion of the country. This is largely due to the dry, dusty environments of the west. Afternoon and evening winds lift dust and debris into the air, resulting in the shorter wavelengths to refract or scatter as discussed above. Thereby creating those picture perfect sunsets.
This lesson is an introduction to the electromagnetic spectrum and specifically visible light. Through hands on experiments, class discussion and exploration students will learn why western sunsets are well known and beautiful.

Preparation

Read background and research any additional information about light.

Collect all materials for student experiments and instructor demonstration. Create electromagnetic spectrum poster and prepare examples of each wave's use. Information about these waves can be found on page eight.

Fill tank with water set up for first sunset demonstration.

Doing the Activity

Introduction: Sunsets
Begin with students doing a mad dash on the question: Why are sunsets red and orange? A mad dash is a 60 second brainstorm students have with each other, where they share everything they know about the topic at hand.

When time is finished, record student thoughts on the board and clear up any extreme misconceptions about light or sunsets.

Lets investigate! Explain to the class the demonstration will model a sunset. Students will record observations at the beginning, middle and end of the experiment, by using the student worksheet. Students will also predict and record what each material in the experiment is modeling in nature, on the same worksheet.

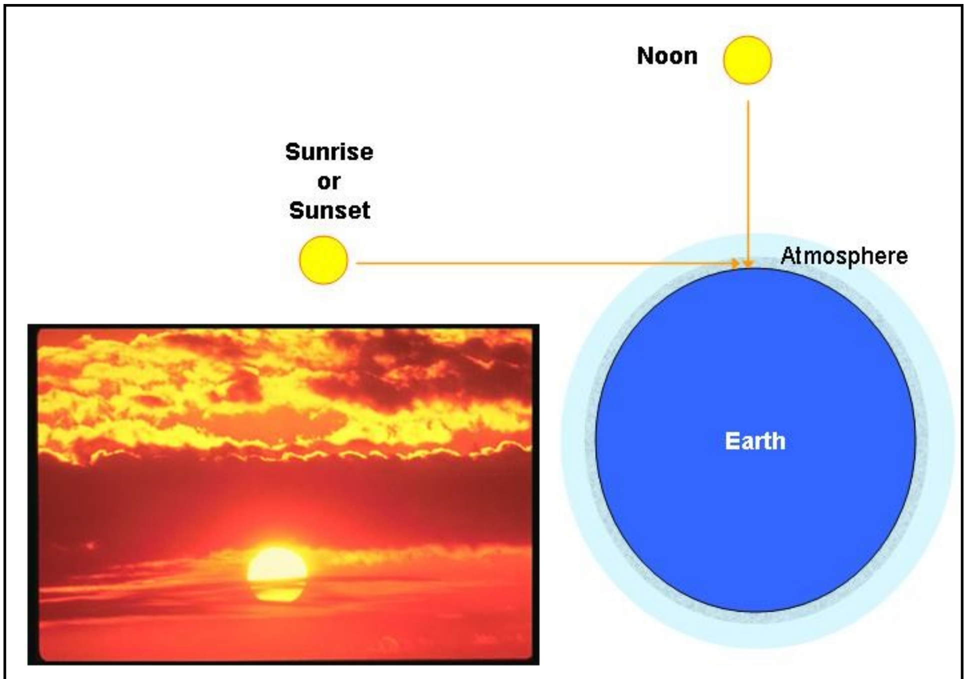
Activity 1: What is Light?
Share with students that light is an important factor in why Nevada has such spectacular sunsets. To understand why, we need to understand light a little bit more. Have students do a second mad dash on the topic of light. When finished, record student thoughts on the board.

Explain to students there are many types of light. Light as we know it is the visible range of the electromagnetic spectrum. Most students will have never heard this definition of light before. Use the electromagnetic spectrum poster to show students where visible light is compared to others. When using this poster briefly identify each type of wave found in the spectrum and give examples of their use.

Activity 2: Visible Light
Focus the class' attention on the visible light spectrum. Ask students if they know what light looks like? What color is it?

Explain to students, they will explore visible light by drawing the visible light spectrum. The goal for this activity is for students to record/draw the visible light spectrum and recognize when all the colors are together, light is white.

Spread materials students may



Angles sunlight hits the Earth

use on the front table in the classroom: CD's, mini lights, prisms, etc. State the goal to the class and emphasize that students need to record what materials they use and to draw the best display of the visible light spectrum in their science journals.

Allow students to explore the different materials freely for 10 to 15 minutes. When finished, have students lay their drawings on their desk and have everyone tour the classroom to compare their classmates' drawings to their own.

Using the electromagnetic poster, show students what light looks like when it is separated. If possible darken the classroom, and use a prism and flashlight to display the spectrum on the walls. Students should copy down the correct sequence of colors in their science journals.

Next, have students hypothesize why these colors are being displayed in this specific order, or are they?

Explain to the class that indeed, the order of these colors are based on two characteristics of light: wavelength and frequency. Define these terms to the class and if time allows, do the ribbon extension activity.

Activity 3: Sunset Experiment
Fill a glass fish tank at least 3/4 full of water. Place a flashlight to the side of the tank, so that the light shines upon a white wall. At this time students should record their initial observation. Then, darken the room as much as possible and add a teaspoon of whole milk to the water. Continue to add a teaspoon of whole milk to the tank one at a time, until the milky-water displays an orange or red light upon the wall. Do not stir the milk into the water. A better result is achieved when the milk simply sinks into the tank.

After the demonstration, allow students to discuss how the sunset occurred and what the materials modeled first with their table groups, then with the entire class. These ideas and predictions will be the focus throughout the lesson.

Material key: flashlight - sunlight, water - sky, milk - particles in the air or dust, tank - atmosphere.

Activity 4: Sunset Revisited
Direct the class' attention back to the original sunset experiment - only water in the tank. Based on what they have learned, challenge students to explain why the sunsets are orange and red?

If students are struggling with this thought, direct their attention to the colors of the sunset. What part of the visible light spectrum is seen? (orange and red)

These colors have longer wavelengths and smaller frequencies than other colors. Ask why it is we do not see the other colors in our sunsets? Does something happen to these colors as they travel through the sky/atmosphere? Refer back to the experiment and ask what part of nature is “mixed” into our sky? (milk - dust!)

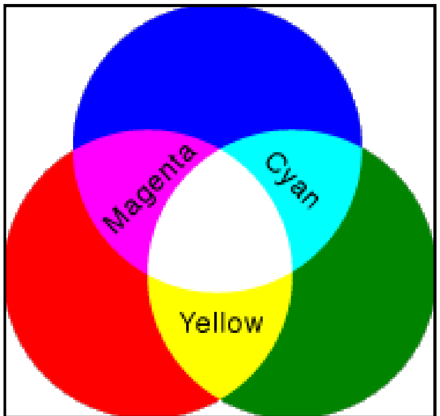
To concrete student understanding, do the sunset experiment a second time. Have students describe what is happening and why it is we see brilliant orange and red sunsets in Nevada.

The last piece of information students should receive deals with the atmosphere. By drawing a diagram of Earth and the atmosphere, show students the two following scenarios:
1. At noon, the sun is directly overhead. The angle that sunlight passes through the atmosphere is nearly 90 degrees.
2. At sunset, the sun sinks toward the horizon. The angle that sunlight passes through the atmosphere is much smaller.

Conclusion

Ask the students at which time of day does the sun’s waves have to travel through more atmosphere? (sunset)

Sunlight enters the atmosphere at a much lower angle and therefore has to pass through more atmosphere before being seen by an observer; air molecules scatter away the shorter wavelengths of light, violet and blue, and the only light which penetrates through the atmosphere are the longer wavelengths of light, yellows,



Making white light

oranges and reds. Which produces beautifully-colored sunsets.

Students should now be able to put all the information together to come up with an explanation as to what makes sunsets certain colors such as red and orange.

Assessment

Assess students on their responses to questions asked throughout the lesson, especially the conclusion. Assess the students on their investigation with CDs and lights and what their final pictures and findings were.

Extensions

White Light Experiment
The following experiment will show students the concept of white light and how the combination of colors creates the white color our eyes see.

Vocabulary

Electromagnetic Spectrum: the complete range of electromagnetic radiation from the shortest waves (gamma waves) to the longest waves (radio waves)

Frequency: the number of vibrations per second in a light wave

Light: electromagnetic radiation with a range of wavelength between 3900 (violet) and 7700 (red) angstroms, capable of stimulating the subjective sensation of sight; sometimes considered to include ultraviolet and infrared radiation as well

Prism: a transparent polygonal solid object with flat faces and a usually triangular cross section, used for separating white light into a spectrum of colors

Reflection: change in direction of a wave front at an interface between two different media so that the wave front returns into the medium from which it originated

Refraction: the change in direction that occurs when a wave of energy such as light passes from one medium to another of a different density, for example: from air to water

Wavelength: the distance between one crest or trough of a wave of light or sound to the next

Materials needed: 3 flashlights, white paper, colored pencils or markers, colored cellophane or filters - blue, green and red.

Cut pieces of colored cellophane and tape one color to the front of each flashlight.

Introduce the idea that white light is composed of different colors of light.
Give each group of students three flashlights covered with

red, green and blue cellophane, a sheet of white paper and tape.

Tape one piece of white paper to the wall or floor.

Demonstrate how to shine each flashlight on the wall. Start by shining one flashlight against the paper. Shine the second to side and slightly overlapping the first light. Do the same with the third flashlight.
Students should then use colored pencils or markers to draw the circles of color as they are seen. Special attention should be given to the areas where the light overlap.

Tape a clean sheet of white paper to the wall or floor. Shine all three flashlight to the center of the paper.

Have students draw and label the colors that are seen. Students should observe that all three colors create a shade of white. Note the degree of "whiteness" will vary depending on the quality of the flashlight and cellophane)

Give each group an object to place in front of a new piece of white paper.

While shining all three flashlights at the center of the paper, students should move closer to or farther from the wall until distinct shadows of colors are seen.
Discuss what new colors are seen when specific combinations of colors are overlapped. Combinations such as blue and red create magenta; blue and green create cyan; red and green create yellow (*The Franklin Institute*).

Wavelength Ribbon Activity
The goal of this activity is to connect with kinesthetic and visual learners on how different wavelengths display different types of frequencies.

Materials needed: 2-3 sets of ribbons - 7 colors to represent the main colors of the visible light spectrum ROYGBIV, rulers or wooden dowels, tape, visible light spectrum picture.
Groups need to first construct their "wavelengths" by taping one strand of ribbon to the end of each ruler. Each group should have seven wavelengths.
Groups are to use the visible light spectrum picture and ribbons to create a life-size model of the all the wavelengths.

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Name:______________________ **Light Observations and Experiments**

Sunset Experiment

Hypothesis: Why are sunsets red-orange?

Materials & Models in Nature

1. Tank . . . . ______________

2. Water . . . . ______________

3. Flashlight . . . . ______________

4. Milk. . . . . ______________

Observations

Beginning

Middle

End

Visible Light Spectrum

Materials used:

Draw your observations here

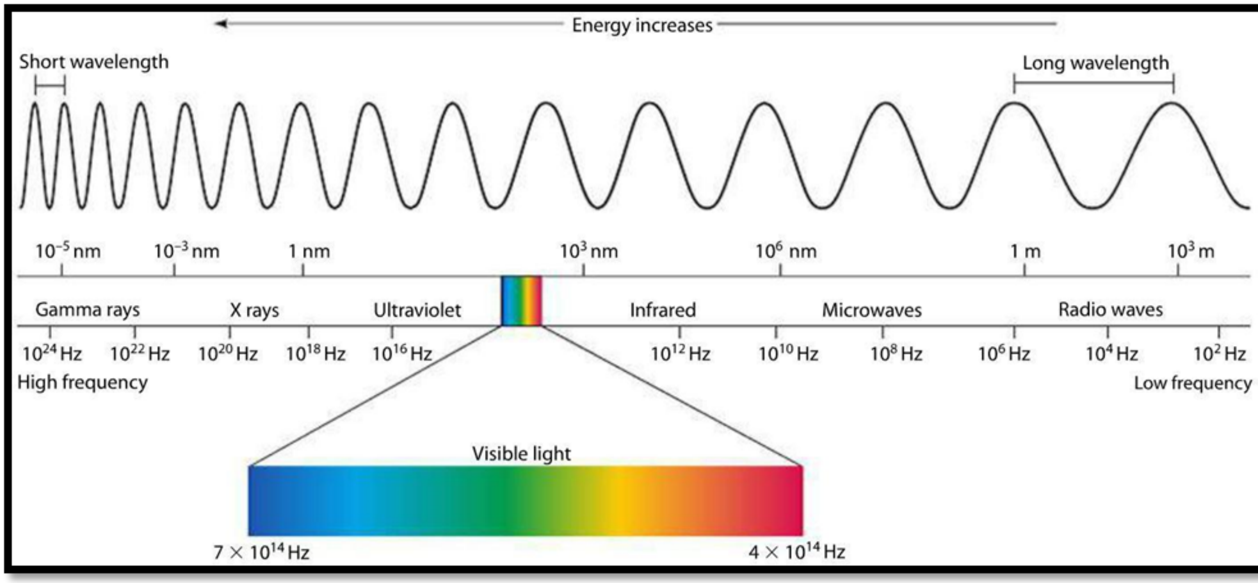
Actual visible light spectrum

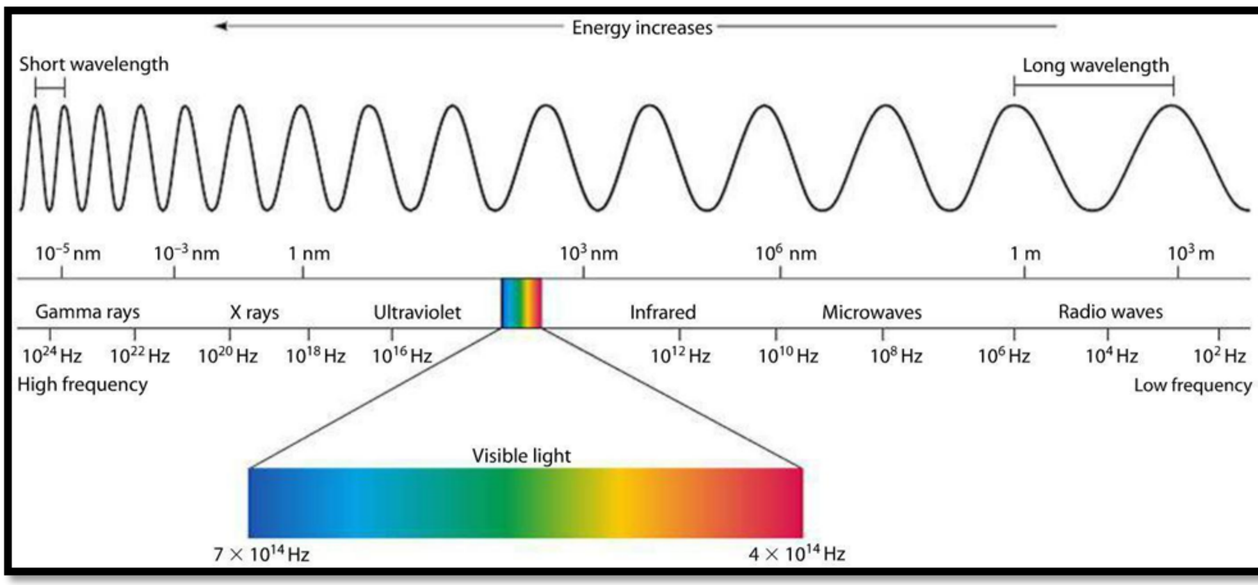
Electromagnetic Spectrum Summary

Low Frequency
Long Wavelength

Type of wave	Typical source	Example of detector	Approximate wavelength	Typical users	Dangers of over exposure
Radio: LW MW VHF	electronic circuits, cool objects	aerial and electronic circuit	1km 100m 1m	communica-tions, radio, TV	safe (unless very concentrated)
Microwaves	electronic circuits, cool objects	aerial and electronic circuit	1cm (10^{-2}m)	communica-tions satellites, telephony, heating water and food	burning, if concentrated
Infra-red (ir)	electronic devices, warm objects, sun	electronic detectors, special film, blackened thermometer	0.1mm (10^{-4}m)	magic eyes in security lighting, remote control (e.g. TV)	burning, if concentrated
Light: Red, Orange, Yellow, Green, Blue, Indigo, Violet	electronic devices(LED), hot objects, sun	eye, film, electronic devices (e.g.LDR)	0.001mm (10^{-6}m)	seeing, photography	burning, blindness, if concentrated
Ultra-violet (uv)	gas discharge, very hot objects, amps, sun	film	0.00001mm (10^{-8}m)	sun-tan lamp, making ions, making Vitamin D	sunburn, skin cancer
X-rays	very fast electrons hitting a metal target	film	10^{-10}m	imaging defects in bones, hidden devices	cell destruction, cell mutation, cancer
Gamma rays (γ)	radioactive nuclei decaying	film, GM tube	10^{-12}m	medical tracers, killing cancerous cells, steralisation	cell destruction, cell mutation, cancer

High Frequency
Short Wavelength


Energy increases
Short wavelength
Long wavelength
10^−5 nm
10^−3 nm
1 nm
10^3 nm
10^6 nm
1 m
10^3 m
Gamma rays
X rays
Ultraviolet
Infrared
Microwaves
Radio waves
10^24 Hz
10^22 Hz
10^20 Hz
10^18 Hz
10^16 Hz
10^12 Hz
10^10 Hz
10^8 Hz
10^6 Hz
10^4 Hz
10^2 Hz
High frequency
Low frequency
Visible light
7 × 10^14 Hz
4 × 10^14 Hz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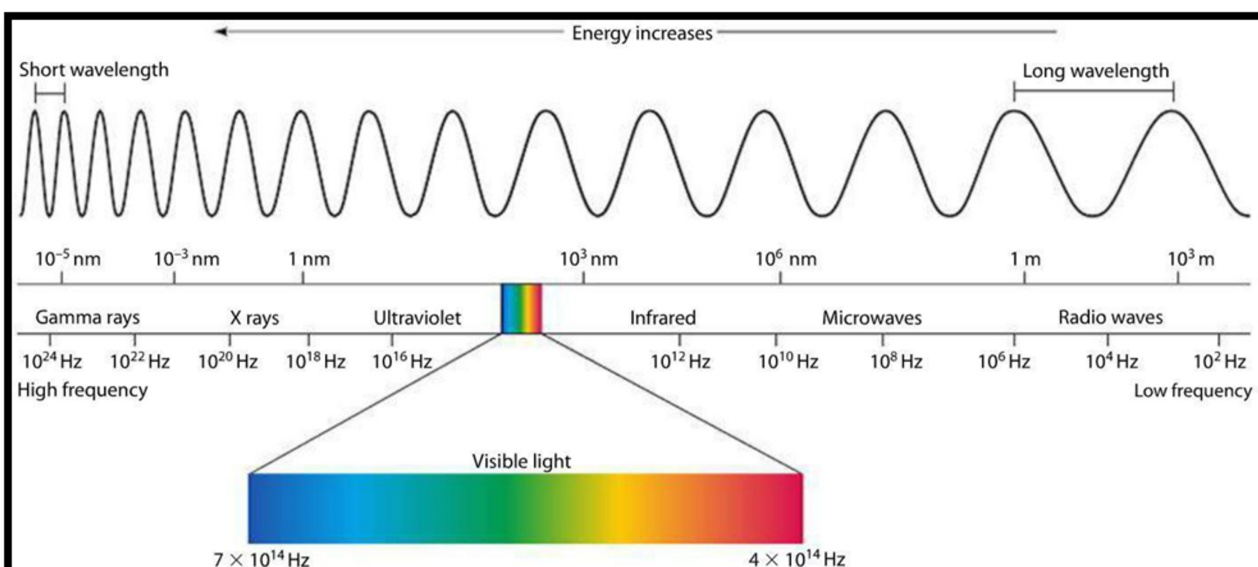
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